

ed by Express Mail
Receipt No. EM3687660405
on 8/6/99
pursuant to 37 C.F.R.1.10.
by Angela Hausmann

1 TITLE OF THE INVENTION

METHOD AND SYSTEM FOR NETWORK MANAGEMENT

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to a network-management method and a network-management system for controlling a network that provides various services.

10 In a certain network configuration, a plurality of nodes (e.g., switches and ATM switches) and cross-connection devices are connected via physical communication lines, and logical paths are established with respect to various services for providing audio, image, and data. In a large-scale network, a plurality
15 of communication-service providers may offer services. In such a case, it is expected to be able to control network with respect to each service or with respect to each communication-service provider.

20 2. Description of the Related Art

There are various proposed schemes for connecting LANs (local area networks) and WANs (wide area networks) together to create a large-scale network and for controlling the created large-scale network. In general, a large-scale network is implemented by
25 employing multi-vendor network elements. Further, the large-scale network may be managed by a single communication-service provider, or may be created and managed by a plurality of communication-service providers. Against this background, there is a scheme
30 for dividing a large-scale network into segments and giving a hierarchical structure to these segments, allowing each network segment to be displayed separately for management purposes and allowing connections inside each segment to be controlled. An
35 example of such a scheme is disclosed in Japanese Patent Laid-open Application No. 6-326706, for example.

Another scheme allows only an administrator

0036976.080599
009080.9269260

1 of a network of a given communication-service provider
to store virtual view information in a table form for
the purpose of controlling the network. This scheme
allows the administrator to attend to network
5 management while insuring overall security between
different communication-service providers. An example
of such a scheme is disclosed in Japanese Patent Laid-
open Application No. 4-230139.

Further, there is a scheme for controlling
10 network by displaying network nodes on a screen by use
of colors for indication of network conditions,
interface-connection conditions, and so on, and by
providing a beeping function using different beep
sounds. When the network fails, a location of the
15 failure is reported to a network administrator by
displaying the location in a different color and
producing an alarming sound. Also, there is a scheme
for controlling network by utilizing GUI (graphical
user interface). Icons and pull-down selections are
20 used for obtaining MIB (management information base)
information, for example, thereby allowing visual
evaluation of current network conditions.

A network uses physical communication lines,
switches, ATM switches, etc., to connect between
25 terminals and also between terminals and information
providers, and renders various services for
transmission of audio data and/or image data, the
Internet, CBR (constant bit rate) transmission, VBR
(variable bit rate) transmission, etc. In a related-
30 art network, conditions of physical communication lines
and nodes such as switches and ATM switches are
displayed on a management screen, thereby allowing a
network administrators to spot a network failure. In
this configuration, however, network conditions cannot
35 be controlled on a service-wise basis. Further, it is
not easy to evaluate whether a spotted network failure
severely affects the services.

0936976-080699
669080-926960

1 Settings of connections for providing
services are usually made by entering commands. When a
network includes multi-vendor network elements, various
commands need to be provided so as to cope with each of
5 different network elements. Because of this, it is
undesirably difficult to set connections in a service-
wise manner.

 Accordingly, there is a need for a network-
management method and a network-management system which
10 allow control and settings to be easily made with
respect to each of different services by providing a
physical network structure and a logical network
structure on a service-wise basis.

15 SUMMARY OF THE INVENTION

 Accordingly, it is a general object of the
present invention to provide a network-management
method and a network-management device which can
satisfy the need described above.

20 It is another and more specific object of the
present invention to provide a network-management
method and a network-management system which allow
control and settings to be easily made with respect to
each of different services by providing a physical
25 network structure and a logical network structure on a
service-wise basis.

 In order to achieve the above objects
according to the present invention, a method of
controlling a network, which includes network elements
30 connected via links and provides services, includes the
steps of creating view-configuration information based
on network-configuration information with respect to
each of the services such that the view-configuration
information is related to the network-configuration
35 information, and displaying a view based on the view-
configuration information with respect to each of the
services, the view including both or either one of a

09369776.080699

1 physical network configuration of the network and a
logical network configuration of the network.

In the method as described above, views
including physical network configurations and/or
5 logical network configurations are presented to a user
(i.e., a network administrator or a service
administrator) to allow the network to be controlled on
a service-wise basis. This is made possible by
creating view-configuration information based on
10 network-configuration information with respect to each
of the services such that the view-configuration
information is related to the network-configuration
information. Because of such a configuration, it is
possible to detect condition changes simultaneously in
15 a plurality of views when the network-configuration-
information has changes in the conditions thereof.
This configuration eliminates inconsistency between
different views.

The same objects can be achieved by the
20 following system according to the present invention.
Namely, a system for controlling a network including
network elements and links includes a database which
stores network-configuration information and view-
configuration information such that the view-
25 configuration information is related to the network-
configuration information, a service-management server
which attends to registering and updating of the
information stored in the database, and defines views
of a physical network configuration and a logical
30 network configuration with respect to each of the
services based on the view-configuration information
stored in the database, a network-management server
which collects information on configurations of the
network elements and the links as well as information
35 on failures, and informs the service-management server
of a change in at least one of the configurations and
the failures for a purpose of the updating, and a

00369776-080699

1 client which displays both or either one of the
physical network configuration and the logical network
configuration with respect to the client's own service
based on the views defined by the service-management
5 server.

Other objects and further features of the
present invention will be apparent from the following
detailed description when read in conjunction with the
accompanying drawings.

10

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is an illustrative drawing showing a
schematic configuration of a network-management system
according to the present invention;

15

Fig.2 is an illustrative drawing for
explaining multiple views of the present invention with
reference to a physical network configuration;

20

Fig.3 is an illustrative drawing for
explaining updating of a database according to the
present invention;

Fig.4 is an illustrative drawing showing a
component configuration corresponding to the system of
Fig.1;

25

Fig.5 is an illustrative drawing showing a
system configuration based on components;

Fig.6 is a table showing database items;

Fig.7 is a table showing database items
relating to reconstruction;

30

Figs.8 and 9 are illustrative drawings
showing a configuration of the database;

Figs.10A and 10B are tables showing contents
and descriptions of the contents with respect to
database items shown in Figs.8 and 9;

35

Figs.11A through 11C are illustrative
drawings for explaining logical network configurations;

Figs.12A through 12D are illustrative
drawings for explaining a trace display;

09369776-080699

1 Fig.13 is an illustrative drawing showing
multiple views;

 Fig.14 is an illustrative drawing for
explaining failure labels and failure levels;

5 Figs.15A and 15B are illustrative drawings
for explaining failure-level information;

 Fig.16 is an illustrative drawing for
explaining failure labels, physical-failure levels, and
service-failure levels;

10 Fig.17 is an illustrative drawing showing
definitions of failure levels;

 Fig.18 is an illustrative drawing for
explaining a spill-over effect of a port failure;

15 Fig.19 is a flowchart of a process performed
at the time of a failure-level change;

 Fig.20 is a flowchart of a process of
creating multiple views;

20 Fig.21 is an illustrative drawing showing an
example of definition files used in a multi-vendor
environment;

 Fig.22 is an illustrative drawing for
explaining making of cross-connect settings;

 Fig.23 is an illustrative drawing for
explaining registration of device-specific parameters;

25 Fig.24 is an illustrative drawing showing a
procedure of cross-connect setting;

 Fig.25 is an illustrative drawing for
explaining setting of a route;

30 Fig.26 is an illustrative drawing for
explaining setting of a route that includes virtual
links; and

 Fig.27 is an illustrative drawing for
explaining setting of a route which includes a node
that can divide a route.

35

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, embodiments of the present

09369776-080699

1 invention will be described with reference to the
accompanying drawings.

Fig.1 is an illustrative drawing showing a
schematic configuration of a network-management system
5 according to the present invention.

The network-management system of Fig.1
includes a service-management server 1, a database 2,
NEM (network-management) servers 3-1 through 3-4, a VOD
(video-on-demand)-service-management client 4-1, an
10 audio-service-management client 4-2, an IP (information
provider)-service-management client 4-3, a
communication-line-rent-service-management client 4-4,
and a network 5.

The service-management server 1 includes a
15 view-definition unit 1-1, a logical-network-layout-
generation unit 1-2, a connection-setting unit 1-3, a
real-time-network-information-update unit 1-4, and a
physical-failure-and-logical-failure relating unit 1-5.

The NEM servers 3-1 through 3-4 collect
20 information about updates of configurations of network
elements, links, and the like as well as information
about failures by tracking or polling operations, and
informs the service-management server 1 of events that
affect network operations. In response, the service-
25 management server 1 updates the database 2. Network
configuration information about the network 5 regarding
ATM switches, high-speed communication lines, and the
like is collected and stored in the database 2 at the
time of a system startup, and is updated as changes are
30 made to the network configuration. Further, one or
more views are stored with respect to different service
types by a view-creation procedure.

The clients 4-1 through 4-4 provide a VOD
service, an audio service, an IP service, and a
35 communication-line-rent service, respectively. These
clients for providing the specific types of services
described above are only an example, and other clients

0936976-080699

1 for other services can be added to the configuration of
Fig.1.

5 A view in the present invention refers to a
unit of control on a GUI (graphical user interface) of
the network-management system. Multiple views refer to
views that are presented as if they were provided on
separate networks corresponding to different services
despite the fact that these services are in reality
provided via a single network. A view can be presented
10 in such a fashion as to show both or either one of a
logical network configuration and a physical network
configuration by finding matches therebetween.

15 A network administrator or a service
administrator selects one or more views from a
presented list of views, so that both or either one of
the logical network configuration and the physical
network configuration are shown on a display screen
(not shown) with respect to the one or more selected
views. On the presented views, a location of failure
20 and an area that is affected by the failure are shown,
and, further, settings of connections can be made.
Further, a view that shows all the elements of the
network with reference to no hierarchical structure is
referred to as a flat view. A view that groups
25 elements according to a region and shows these elements
in a framework of a hierarchical structure is referred
to as a domain view.

30 Fig.2 is an illustrative drawing for
explaining multiple views of the present invention with
reference to a physical network configuration.

35 In Fig.2, a physical network 10 shows a
physical configuration of a network. An audio-service
view 11, an Internet-service view 12, and a VOD-service
view 13 show a physical configuration of a network for
providing a corresponding service.

An audio service is provided via a network
which includes PBX switches connected via ATM switches,

09369776.080699

1 for example. An Internet service is provided via a
network in which routers are connected via ATM
switches. Further, a VOD service is rendered by using
a network in which a VOD server and VOD terminals are
5 connected via ATM switches. A VOD-service
administrator, for example, controls the network for
providing the VOD service by using the physical network
configuration of the VOD-service view 13 or a logical
network configuration that can be presented as
10 appropriate.

Fig.3 is an illustrative drawing for
explaining updating of a database according to the
present invention. Fig.3 shows the database 2, the
service-management server 1, a NEM server 3 that is one
15 of the NEM servers 3-1 through 3-4, and a network
element 21 that may be a switch or an ATM switch
provided in the network 5 of Fig.1. The NEM server 3
is generally located in a close proximity of the
network. On the other hand, the service-management
20 server 1 may be provided in a remote location and
connected via another network (not shown) since the
service-management server 1 is supposed to be connected
to a plurality of NEM servers 3.

Information about all the network elements
25 (21), which are subject to network management, is
collected at the time of a system startup. When
collecting update information about the network element
21 or information about a failure, the NEM server 3
uses an element-type-dependent-conversion function 22
30 to convert the collected information to database-
registration information 23. Then, the NEM server 3
compares the database-registration information 23 with
old database-registration information 24 by use of a
comparison function 25, and replaces the old database-
35 registration information 24 with the database-
registration information 23 only if there is a change.
Further, the NEM server 3 sends the database-

00369775-000000

1 registration information 23 to the service-management
server 1. In response, the service-management server 1
uses a database updating function 26 to update the
database 2. The database-registration information 23
5 is transferred only when service related information
collected from the network exhibits a change. This
achieves updating of the database 2 with a small amount
of data transfer.

Fig.4 is an illustrative drawing showing a
10 component configuration corresponding to the system of
Fig.1.

The service-management server 1 connected to
the database 2 includes a client manager 31, a view
controller 32, a user manager 33, a multi-domain
15 manager 34, and local-domain managers 35 through 37.
The local-domain managers 35 through 37 absorb
differences in conditions that vary between different
types of network elements such as ATM switches,
SONET/SDH elements, LAN elements, etc. Each of the NEM
20 servers 3-1 through 3-4 includes a node discovery 38
and an element-access module 39. Further, a client
interface 40 provides GUI based on information obtained
from the service-management server 1.

Fig.5 is an illustrative drawing showing a
25 system configuration based on components.

In Fig.5, components of Fig.4 are shown in a
hierarchical structure, which separates element-type-
dependent objects and element-type-independent objects.
Further, the element-type-dependent objects are
30 classified into network-type-dependent objects and
network-type-independent objects. As shown in Fig.5,
the element-access module 39 is attached to each
network element such as an ATM switch in the network 5,
and absorbs element-type-dependent differences of
35 conditions. Each of the local-domain managers 35
through 37 is provided for a network of a different
type, and absorbs differences in conditions that differ

09369775-080699
669080-926960

1 depending on a network type such as ATM, SONET, SDH,
IP, etc.

The multi-domain manager 34 attends to
overall control of the network 5. The client interface
5 40 provides the GUI based on the information obtained
from the service-management server 1. The user manager
33 of Fig.4 is used for controlling relations between
passwords and views where these passwords are required
when a user (network administrator) accesses the GUI.
10 The node discovery 38 performs a function to add or
delete a network element as the network element newly
becomes an object for management or becomes obsolete as
an object for management. This achieves dividing of
processes by network areas.

15 Fig.6 is a table showing database items.

The database includes database items,
information obtained from network elements, and
conversion methods. Fig.6 shows a network
configuration, a node condition, a link condition, a
20 connection route, and a connection condition as
examples of database items relating to the service-
management server 1. With regard to the connection
route, for example, information is collected from
cross-connect devices of a network, and a connection
25 route is established by connecting the cross-connect
devices together. When there is a change in the cross-
connect devices, information about the route is
modified partially. When there is no cross connection
any longer, the connection route is deleted from the
30 database.

Fig.7 is a table showing database items
relating to reconstruction.

The database includes, as events, a node
failure, a node failure recovery, a connection
35 creation, a connection modification, a connection
deletion, and a user request. These events are
provided as entries together with expected

1 modifications and items to be collected. The user
request is made by a user (i.e., a network
administrator or a service administrator). With regard
to the event of the connection creation, for example,
5 addition of a new connection is expected as a
modification, and a route of the added connection is an
item to be collected.

Figs.8 and 9 are illustrative drawings
showing a configuration of the database.

10 The database is divided into a network-
configuration-information unit 51 and a view-
configuration-information unit 52. Connections between
these two units are shown in Figs.8 and 9 by numerals
(1) through (5).

15 Figs.10A and 10B are tables showing the
contents and descriptions of the contents with respect
to database items shown in Figs.8 and 9.

Fig.10A shows database items relating to
network-configuration information. JVvNode represents
20 nodes, for example, and stores therein information
about network elements. By the same token, JVvLink
represents links, and stored therein information about
communication lines between the network elements.
Fig.10B shows database items relating to view-
25 configuration information. JVvView represents views,
for example, and stores therein information used for
management of a plurality of views. JVvViewDomain
represents domains, and indicates a unit of control
into which a view is divided.

30 Ports and connections are linked as network-
configuration-information items so as to make it
possible to detect a connection failure at the time of
a port failure. Further, three network-configuration-
information items, i.e., the node JVvNode, the link
35 JVvLink, and the connection JVvConnection, are
registered in the view configuration as a view node
JVvViewNode, a view link JVvViewLink, and a view

09369776-080599

1 connection JVviewConnection. This makes these items an
object for management. In this manner, a view XXX as a
view-configuration-information item is linked to a
network-configuration-information item XXX, so that it
5 is possible to detect a condition change simultaneously
in a plurality of views when the network-configuration-
information item XXX has a change in the condition
thereof. This configuration eliminates inconsistency
between different views.

10 Figs.11A through 11C are illustrative
drawings for explaining logical network configurations.
Figs.11A and 11B show a case in which network elements
connected to ports of a node being managed are defined
as edges, and Fig.11C shows a case in which a virtual
15 terminal is connected at either end of a connection.

In Fig.11A, a plurality of connections
(logical network) are established between a pair of
edges, and intervening network elements are hidden from
the view, thereby showing only the connections between
20 the edges. In Fig.11B, edges are defined, and a
network configuration including nodes and links is
presented by showing network elements such as switches
that have connections passing therethrough. In
Fig.11C, a network configuration is shown as having a
25 virtual terminal connected to either end of a
connection. Although Fig.11C shows network elements
along with the connections, these intervening network
elements such as switches may be hidden from the view.

30 Figs.12A through 12D are illustrative
drawings for explaining a trace display.

Fig.12A shows a logical network configuration
comprised of edges 61 through 65 and connections
therebetween, and corresponds to the case of Fig.11A.
By selecting the edges 61 and 64, for example, the
35 corresponding connection is displayed as a thick line
as shown in Fig.12B. Fig.12C shows a physical network
configuration comprised of edges and network elements,

0936076.080699

1 and corresponds to the case of Fig.11C. The edges 61
through 65 are connected via network elements 66
through 69. A point in the network is selected, and a
connection is traced from the selected point until the
5 trace reaches an edge. The traced connection is then
displayed. As shown in Fig.12D, for example, a trace
from the edge 61, the network element 66, the network
element 69, the network element 68, to the edge 64 is
displayed by using thick lines. In this example,
10 distinctions are made by use of thick lines and thin
lines, but may be made by using different colors.

Fig.13 is an illustrative drawing showing
multiple views. Fig.13 shows a case in which a VOD
service is provided. In a system of Fig.13, a VOD
15 server 71 and a VOD client 72 are connected via ATM
switches 73 and transit devices 74. A network-control
terminal 75 displays a network configuration based on
control information 78 that is provided specifically
for a network administrator or a service administrator
20 of this terminal. By the same token, network-control
terminals 76 and 77 display respective network
configurations based on control information 79 that is
provided specifically for network administrators or
service administrators of these terminals.

25 As shown in Fig.11A, the network-control
terminal 76 displays connections between the edges
(i.e., between the OVD server 71 and the VOD client
72). The network-control terminal 77, as shown in
Fig.11B, presents physical network configuration
30 including the edges and the network elements. When a
failure is indicated in the logical network
configuration displayed on the network-control terminal
76, for example, the physical network configuration
shown on the network-control terminal 77 is used so as
35 to inform the network administrator of a location of
the failure in the network. The network administrator
can then attend to recovery.

09369776-000699

1 Network elements and/or network types can be
added by modifying the network-configuration
information and the view-configuration information, and
API (application programming interface) that provides
5 information necessary for a network administrator is
defined. API is activated with respect to device-type-
dependent objects or network-type-dependent objects
that are newly added, thereby making it possible to
modify the database and the GUI display. Such
10 modification includes creation/modification/deletion of
nodes, links, and connections, modification of
connection routes, recovery of node failures and port
failures, creation/modification/deletion of view nodes,
view links, view connections, domains, edges, views,
15 service templates, separate-failure definitions, and
service-failure definitions, etc.

Multi-vendor network elements include a
device having only a single slot to insert a card and a
device which can accept two cards. Not only such
20 differences in device structures but also differences
in parameter settings attribute to differences between
network elements (devices). Further, all the network
elements in the network are often not in compliance
with the same standards. For example, a new-version
25 element and an old-version element may coexist with
respect to different vendors.

In consideration of this, data for
representing a port is controlled as a character string
that can be recognized by element-access modules EAM
30 each provided specifically for a particular device type
(element type). The character string represents a port
address. Further, the local-domain manager LDM and the
multi-domain manager MDM recognize the character string
of the port address as data that simply represents a
35 single port, and are not aware of details of the
character strings.

Representation of connections is also

09369776-000699

1 different depending on network types. In an ATM
network, a connection corresponds to a virtual channel,
and is represented by VPI/VCI values. Other types of
networks, however, do not employ such representation.
5 In consideration of this, data representing a
connection is controlled as a character string that can
be recognized by local-domain managers LDM and multi-
domain managers MDM each provided specifically for a
particular network type. This character strings
10 represents a connection address.

A cause and details of a failure differs from
network element to network element. Because of this,
the network-service-control system generalizes a
failure of each network element, and converts the
15 failure into a failure level for the management
purposes. Element-type-dependent objects control
relations between failure labels and failure levels.
Namely, an element-type-dependent object analyzes a
failure code received from a network element, and
20 converts the code into a failure label. Then, the
failure label, which is device-dependent, is converted
into a failure level.

Fig.14 is an illustrative drawing for
explaining failure labels and failure levels. Fig.14
25 shows relations between failures (failure labels) and
failure levels with respect to network elements A and
B. Here, the failure levels are provided in two folds,
i.e., in terms of physical failures as well as service
failures. A failure of a hard-drive device of the
30 network element A, for example, is regarded as a
serious failure as a physical failure, and is regarded
as a failure as a service failure since there is a
possibility that the service has to be stopped. A
failure of a ventilator fan of the network element B is
35 treated as a warning in terms of the physical failure
(to alarm a possible temperature hike), and is treated
as a normal condition in terms of the service failure

0936976-080699
669080-946960

1 since the service can continue.

Further, a power malfunction of the network element B is a minor failure as a physical failure level, and is regarded as a normal condition as a
5 service failure level.

Figs.15A and 15B are illustrative drawings for explaining failure-level information. Fig.15A shows physical-failure-level information, and Fig.15B illustrates service-failure-level information.

10 When a failure name (corresponding to the failure level of Fig.14) is "warning", a failure level is "-1". Further, a color of icon is gray, and an alarm-sound ID is "0". When a failure name is "normal", a failure level is zero, and an icon color
15 is green with an alarm-sound ID being "0". Further, a failure name "serious failure" corresponds to a failure level "3", an icon color "red", and an alarm-sound ID "3". When a failure name is "normal" in the list of service failures of Fig.15B, a failure level is "0",
20 and an icon color is green with an alarm-sound ID being "0". A failure name "failure" corresponds to a failure level "1", an icon color "red", and an alarm-sound ID "1".

Fig.16 is an illustrative drawing for
25 explaining failure labels, physical-failure levels, and service-failure levels. Fig.16 shows an example of a network ATM switch.

When a failure label is "clock failure", for example, a physical-failure level is "3", and a
30 service-failure level is "1". When a failure label is "UPS failure" (UPS: unstopable power source), a physical-failure level is "3", and a service-failure level is "1". Further, a temperature failure corresponds to a physical-failure level "2" and a
35 service-failure level "0". In this manner, relations between failure labels and failure levels are defined with respect to each network element, and are

0036976.000699

1 controlled by using a table format.

Fig.17 is an illustrative drawing showing definitions of failure levels.

Network-element-management units 81 through 83 correspond to the element-access module 39 of Fig.4, and have a function to absorb device-type-dependent differences. The network-element-management units 81 through 83 assign failure levels to failure labels that are defined with respect to network elements A, B and C. The failure levels are unique in the entire system. The failure levels indicate a degree of an effect that is taken on data flows running through connections. A failure level "0" indicates a normal condition, and a failure level "1" indicates a warning (no effect at present). Further, a failure level "2" represents a minor failure (some effect on part of services), and a failure level "3" corresponds to a serious failure (stoppage of service). In addition, a failure level "4" indicates a critical condition (service may be stopped for a long time).

The network-element-management unit 81 provided for the network element A assigns a failure level "1" to a clock failure, a failure level 2 to a switch failure, and a failure level 3 to an adaptor failure. In the network-element-management unit 82 provided for the network element B, a clock failure has a failure level "1", and a hard-drive failure has a failure level 2. This means that a hard-drive failure may affect part of services.

30 The network-element-management units 81
through 83 keep record of statuses of the network
elements A through C by trapping or polling the network
elements A through C. The network-element-management
units 81 through 83 attend to control by distinguishing
35 failures regarding the entire node from failures
regarding a port that is part of the node. A failure
of a port only affects a connection that uses this

1 port. A failure of the entire node, on the other hand,
affects all the connections relating to the node. It
should be noted, however, that a failure of a port may
affect other ports.

5 Fig.18 is an illustrative drawing for
explaining a spill-over effect of a port failure.

In Fig.18, a node 90 of a network 5 includes
ports 91 through 98. When a failure occurs at the port
95 which is shown by a solid circle, connections #1 and
10 #2 are affected since the ports 91 and 92 are connected
to the failed port 95.

The network-element-management units 81
through 83 collect information about failures of nodes
and ports by a polling process or a trap process. When
15 failures are observed at a node or a port, the highest
failure level of all is retained as a failure level of
this node or port. The highest failure level is
compared with a prior failure level, and is reported as
an event to other objects if the comparison indicates a
20 change. In Fig.17, for example, the network-element-
management unit 81 retains the highest failure level
"3", and the network-element-management unit 82 retains
the highest failure level "2". By the same token, the
network-element-management unit 83 maintains the
25 highest failure level "3".

A failure level of each connection is
detected by a failure-level-change event of a node or a
port. If a plurality of nodes or ports suffer failures
along a route of a given connection, the highest
30 failure level of all is regarded as a failure level of
the given connection. When a failure level of a
connection changes, an event is issued.

Fig.19 is a flowchart of a process performed
at the time of a failure-level change.

35 Fig.19 shows schematic operations of a
network element, a corresponding network-element-
management unit, a network-management unit, a database,

09369776-080699

1 a GUI, and an event-management unit. The network-
element-management unit serves to absorb differences in
various failure information between network elements of
different types. A request by a GUI user (network
5 administrator or service administrator) initiates an
operation of the database to collect network-
configuration information. Based on the obtained
network-configuration information, a topology map
(physical network) and a service map (logical network)
10 are displayed.

When obtaining the network-configuration
information, the database requests the network-
management unit to collect the network-configuration
information, and the network-management unit transfers
15 the collected network-configuration information to the
database. Further, the network element informs the
network-element-management unit of failure information
through a trapping operation triggered by the failure
or through a polling operation. The network-element-
20 management unit obtains a failure level, and determines
the highest failure level. The network-element-
management unit further compares the highest failure
level with the prior highest failure level, and informs
the event-management unit of a change in a node-failure
25 level if the comparison finds a change. If the
comparison finds no change, the highest level is
determined with respect to a port. Failure checks are
supposed to be performed separately between a node and
a port. Therefore, a failure check is made with
30 respect to a port even if there is a change in the
node.

In response to the notice of the change in a
failure level, the event-management unit informs the
GUI, the database, and the network-management unit of
35 the change in a node-failure level. In response, the
GUI updates the topology map, and the database updates
the contents thereof. Also, the network-management

0936976-080699

1 unit checks a connection-failure level to determine if
there is a change from a previous connection-failure
level. If there is no change, a check of a link-
failure level is made. If there is a change from the
5 previous connection-failure level, the change in a
connection-failure level is reported to the event-
management unit. This procedure is repeated as many
times as there are connections.

The network-element-management unit checks
10 the highest failure level of the port, and determines
if there is a change from the previous one. If there
is no change, the procedure ends. If there is a
change, the network-element-management unit notifies
the event-management unit of the change in a port-
15 failure level. This operation is repeated as many
times as there are ports. The event-management unit,
responding to the notice of the change in a port-
failure level, forwards the notice to the network-
management unit and the database. The database updates
20 the contents thereof, and the network-management unit
checks a link-failure level to see if the link-failure
level is changed from the previous one. In there is no
change, the procedure ends. If there is a change, a
change in a link-failure level is reported to the
25 event-management unit. The event-management unit then
informs the database and the GUI of this change. The
database updates the contents thereof, and the GUI
updates the topology map. A check of a connection
failure may be made from port failures.

30 Fig.20 is a flowchart of a process of
creating multiple views.

Fig.20 shows schematic operations of a
network-element-management unit, a network-management
unit, a view-management unit, a database, a GUI, and an
35 event-management unit. A network administrator or a
service administrator using the GUI requests the view-
management unit to create a view. In response, the

0936973-080699

1 view-management unit requests the database to collect
network-configuration information. Based on the
collected network-configuration information, view
configurations are obtained in accordance with
5 conditions specified in the view-creation request. The
obtained view configurations are registered in the
database.

The database informs the view-management unit
of a completion of the view-configuration registration.
10 In response, the view-management unit notifies the GUI
of a completion of view creation. The GUI requests the
view configuration registered in the database, and
displays a topology map (physical network) and a
service map (logical network) in accordance with the
15 view configuration obtained from the database.

When the network element sends a
node-failure-level-change notice to the event-
management unit, the event-management unit notifies the
network-management unit, the view-management unit, and
20 the database of this fact. The network-management unit
checks a connection-failure level, and decides whether
there is a change from a previous level. If there is a
change, the network-management unit informs the event-
management unit of a connection-failure-level change.

25 The view-management unit obtains relevant
views in response to the notice from the event-
management unit, and reports a change in a view-node-
failure level to the event-management unit. In
response, the event-management unit requests the GUI to
30 change the topology map, and the GUI attends to the
updating process.

In response to the notice of the connection-
failure-level change from the network-management unit,
event-management unit informs the view-management unit
35 and the database of this fact. The view-management
unit then obtains relevant views, and reports a change
in a view-connection-failure level to the event-

09369776-080699

1 management unit. Also, the database updates the
contents thereof.

The event-management unit receives the notice
of the change in a view-connection-failure level from
5 the view-management unit, and reports this to the GUI.
The GUI updates the service map accordingly. In the
above procedure, if there is no change in the
connection-failure level from the previous one, the
procedure comes to an end.

10 One way to create views is to select all the
network elements and communication lines that a user
(network administrator or service administrator)
desires to display, and such a selection is made on the
GUI (i.e., on a network-configuration layout).
15 Connections provided by the selected network elements
and the communication lines are automatically extracted
and registered as the views.

Another and second way to create views is to
select all the connections that the user wishes to
20 register as views, and such a selection is made on the
GUI which shows a list of all the connections managed
by the network-management system. All the network
elements and communication lines that make up the
selected connections are automatically extracted and
25 registered as the views. A third way to create views
is to select all the terminals (ports of network
elements) that the user wishes to register, and such a
selection is made on the GUI of the network-management
system. All the connections that are connected to the
30 selected terminals are automatically extracted and
registered as the views. Connections, network
elements, and communication lines that are added during
operations are added to the views in real time.

A fourth way to create views is to select
35 attribute conditions on the GUI of the network-
management system with regard to connections the user
desires to register as the view. The system

093697E-080699

1 automatically extracts all the connections that match
the selected conditions as well as network elements and
communication lines relating to the extracted
connections, and registers these as the views.
5 Connections, network elements, and communication lines
that are added during operations are added to the views
in real time. A fifth way to create views is to
select, on the GUI of the network-management system,
names of services that the user wishes to register as
10 the views. As the same in the above, connections,
network elements, and communication lines that are
added during operations are added to the views in real
time.

A sixth way to create views is that the user
15 selects edges on both ends of routes running through
the network so as to extract intervening paths and
network elements between the selected edges. When
there is a change during system operations, the
contents of the views are updated based on the
20 database.

The user who created the views as described
above is provided with an authorization to update views
and set/delete connections used in the views. Further,
if a user creates the views for one or more services,
25 the user can access the views, and, also, can select
other users who can access the views.

In general, networks are comprised of network
elements provided by more than one vendor. In such a
network having a multi-vendor environment, settings of
30 connections may not be made in the same fashion between
different network elements because of differences in
parameters to be used. In consideration of this,
connection attributes are defined with respect to each
of the provided service. This is done in such a manner
35 as to comply with established standards such as those
of the ITU-T.

Fig.21 is an illustrative drawing showing an

003697E-080699

1 example of definition files used in a multi-vendor
environment. Fig.21 shows a case where definitions are
provided for connection settings.

5 As shown in Fig.21, a service-definition file
101 is created with respect to each service 100. The
service-definition file 101 is so created as to comply
with certain standards as described above. Further,
cross-connect-setting-definition files 104 through 106
are provided to be service-type dependent or device-
10 type dependent, and conversion rules 104 are generated
on a device-type-wise basis so as to provide conversion
rules between the service-definition file 101 and the
cross-connect-setting-definition files 104 through 106.

15 The cross-connect-setting-definition files
104 through 106 are created on the device-type-wise
basis or on the service-type-wise basis as described
above. The contents of the cross-connect-setting-
definition files 104 through 106 are as follows.

A) Network Element 1

20 ServiceName = VOICE;
 QoS = 1;
 Assing = Peak;
 CR = 100; and so on

B) Network Element 2

25 ServiceName = VOICE;
 ConnType = both;
 ServiceCategory = CBR;
 PriorityClass = high;
 PCR_CLP0 = 12;
30 PCR_CLP0+1 = 12;
 OAM = ON; and so on

Fig.22 is an illustrative drawing for
explaining making of cross-connect settings.

35 At the time of connection setting, element-
access modules 113 and 114 are used for making cross-
connect settings to network elements 115. Parameters
necessary in this process include common parameters

09369776-080699

1 such as input-side connection addresses and output-side
connections addresses as well as device-type-dependent
(device-specific) parameters. The element-access
modules 113 and 114 receive common parameters and
5 service names from an upper-level component 111, and
looks for device-specific parameters based on the
service names. Here, the device-specific parameters
are kept in a storage of a database 112. The element-
access modules 113 and 114 thus can make cross-connect
10 settings by using the common parameters and the device-
specific parameters.

Fig.23 is an illustrative drawing for
explaining registration of device-specific parameters.

A set of service-definition files includes a
15 common service-definition file 116 and device-specific
service-definition files 117 through 119. Only one
common service-definition file 116 is provided in the
system, and is used for controlling service names and
descriptions of the services. The device-specific
20 service-definition files 117 through 119 are provided
on the device-type-wise basis. When the device-
specific service-definition files 117 through 119 are
registered in the database 112, all the device-specific
parameters are updated with respect to devices which
25 are to be controlled by the service-definition files.

A format of the common service-definition
file 116 may be as follows, for example.

```
statement := definition-statement|comment-statement
definition-statement := ' Service='name','description
30 comment-statement := '#'comment|[blank line]
name := [character string]
description := [character string]
comment := [character string]
```

Definitions of service names and services may
35 be as follows.

```
Service = [name, description]
Service = [name, description]
```

1

•
•
•

5 For example, these definitions may be given
as follows.

Service = VOD, VOD service

Service = Audio, Audio service

10 A blank line or a line starting with "#" is
regarded as a comment line. A format of the device-
specific service-definition files 117 through 119 may
be as follows.

statement := selection-statement|

definition-statement|comment-statement

selection-statement := 'ServiceName='name

15 definition-statement := key='value

comment-statement := '#'comment|[blank line]

name := [character string]

key := [character string]

value := [character string]

20 comment := [character string]

Selection sentences, definition sentences,
comment sentences, and so on are also defined. A
definition of the selection sentence defines device-
specific-parameter values, and the element-access
25 modules define keys specifically with respect to
respective device types.

Fig.24 is an illustrative drawing showing a
procedure of cross-connect setting.

30 When a network administrator or a service
administrator requests to add a service definition by
using the GUI, the database returns a response to the
GUI. Then, the GUI notifies the event-management unit
of an addition of a service. The event-management unit
sends a relevant request to the network-element-
35 management unit. The network-element-management unit
requests the database to obtain the service definition,
and the database sends the requested service definition

0936976.080699
669080" 94.6960

1 to the network-element-management unit.

Further, the GUI sends a connection-setting request to the network-management unit. The network-management unit determines a route in accordance with the connection-setting request, and sends a cross-connect-setting request to each of the network-element-management unit that relates to the determined route. In response to the cross-connect-setting request, the network-element-management unit changes parameters in accordance with the service definition, and makes cross-connect settings to a relevant network element (i.e., a cross-connect device). After receiving a notice of completion of setting from the network element, the network-element-management unit notifies the GUI of the completion of cross-connect setting via the network-management unit.

Fig.25 is an illustrative drawing for explaining setting of a route.

In Fig.25, triangle symbols (1)-(8) represent edges, and letters A-J encircled or put in a square represent nodes. Further, letters (a)-(k) and (a1)-(a15) indicate links. Thin lines are used for a single link, and thick lines are used for a plurality of links. A physical network configuration is presented as a view as shown in Fig.25. Then, a blue color may be used for representing a unselected status or a no-setting status, and a yellow color may be used for indicating a selected status of a route (but details are not yet set). Further, an orange color may mean a selected status of a route with details thereof being set, and a gray color may indicate that all the settings are made to a route.

Details of settings indicate which one of a plurality of links is selected if there is more than one link, and show a selected status if there is only one link. In the case of a node, details of settings determine all items of route-specific attributes. In

1 the case of an edge, details of settings indicate a
selected status at all times.

At an initial status, no setting is in place,
so that every element is displayed in blue. When a
5 route is to be established between the edges (1) and
(7) of Fig.25 in the case of point-to-point permanent
virtual circuits (P-P PVC), the edge (1) is first
selected. As a result, the edge (1) is displayed in
orange. Thereafter, a node A connected to the edge (1)
10 is selected, thereby adding the link (a) to the route.
As a result, the link (a) as well as the edge (1) are
shown in orange, and the node A is presented in yellow,
indicating that the route is selected but details are
not yet set.

15 After this, the node D along the route toward
the edge (7) is selected to indicate the link (a2)
between the node A and the node D. By doing this, an
output-side port of the node A and an input-side port
of the node D are automatically set based on the
20 configuration information about the nodes A and D. The
links (a1) is shown in orange, and the node D is
displayed in yellow.

In the same manner, the nodes G and J are
selected to elect the links (a7) and (a10), thereby
25 determining the route between the edge (1) and the node
J. Finally, the edge (7) is selected to complete the
route, so that the links (1), (a2), (a7), (a10), and
(j) as well as the node A, D, G, and J are shown in
orange indicative of a status that details are set.
30 After confirming what is displayed, a cross-connect
request is issued. In response, cross-connect-setting
information matching each node type is sent out from
the database. With respect to the node G, for example,
cross-connect-setting information for connecting the
35 links (a7) and (a10) together is obtained. In this
manner, the route as shown in dashed lines is
established between the edge (1) and the edge (7),

09369776-080699

1 allowing communication therebetween.

In the case of the edge (7) being a VOD server, for example, a service administrator of the VOD service displays a view of the VOD service, and attends to connection settings by following the procedure as described above based on the displayed view. Alternatively, the edges (1) and (7), for example, are selected, and a route connecting between the selected edges (1) and (7) may be automatically selected in such a manner as to employ as small a number of nodes and links as possible based on the network-configuration information.

Further, canceling of a route selection is possible. For example, the selection of the route of the above example needs to be canceled by starting from the node G. When selections of the link (a7), the node G, the link (a10), the node J, and the edge (7) are nullified, information on the output-side port of the node D is reset, so that the node D falls into a status of no-detail setting. As a result, the node D is changed from an orange color to a yellow color. Starting from this condition, the nodes F, I, G, and J may be selected successively so as to establish a different route between the node (1) and the node (7).

Fig.26 is an illustrative drawing for explaining setting of a route that includes virtual links. Fig.26 shows a case where P-P S-PVC is employed, and uses the same reference numerals and letters for the same elements as those of Fig.25.

In Fig.26, the edge (1), the link (a), the node A, and the link (a1) are already set with regard to details thereof, and the node F has a route-specific attribute thereof set to S-PVC Calling. When the node G is added to the route, a virtual link shown by a dotted line is displayed despite the fact that there is no physical link between the node F and the node G. This virtual link is presented in orange.

09369776-080699

1 After this, the node J is selected to choose
the link (a10) between the nodes G and J, and the edge
(7) is selected to choose the link (j). As a result, a
route is established between the edge (1) and the edge
5 (7) via the link (1), the node A, the link (a1), the
node F, the virtual link, the node G, the link (a10),
the node J, and the link (j). IF the node I is
selected rather than selecting the node G, the link
between the nodes F and I is displayed by a dotted
10 orange line indicative of a virtual link despite of the
fact that there is a physical link (a4) between the
nodes F and I.

When the route selection is canceled by using
the node G as a base point, only a selection on the S-
15 PVC Called side is reset. As a result, a route made up
from the edge (1), the link (a), the node A, the link
(a1), and the node F remains after the canceling of the
selection. If the route selection is canceled by using
the node F as a base point, the selection is reset on
20 both the S-PVC Calling side and the S-PVC Called side.

Fig.27 is an illustrative drawing for
explaining setting of a route which includes a node
that can divide a route.

When the node G that can divide a route is
25 included along the route indicated by dotted lines
between the edge (1) and the edge (7), the node I can
be selected by indicating the node G as a base point.
When this selection is made, the link (a8) between the
node G and the node I is automatically set. Then, the
30 edge (5) and the link (g) are selected, for example, so
that a route between the edge (1) and the edge (5) is
established. Further, if the node B is selected by
using the node G as a base point, the link (a9) is
automatically set between the node G and the node B.
35 In this manner, the route indicated by dotted lines is
established between the edge (1) and the edge (7) along
with the branch routes originating from the node G.

09369776-080699

1 Canceling of the selection is performed in
the same manner as described in the previous example.
When the node I is used as a base point to cancel the
selection, a route from the node G to the edge (5) is
5 reset. Namely, the node I, the link (a8), the link
(g), and the edge (5) are canceled. It should be noted
that settings can be made to another branch route after
the canceling of selection.

As described above, the present invention
10 controls views on a service-wise basis when a plurality
of services are provided by a network. Further, when a
failure occurs, it is easy to evaluate whether the
failure affects services, making it easier to layout a
countermeasure for the failure. Moreover, the preset
15 invention provides a means that allows connection
settings to be easily made with respect to each
service, and absorbs differences in device types when
multi-vendor network elements are used. Such means
makes it easier to add/delete an object to be managed.

20 Further, the present invention is not limited
to these embodiments, but various variations and
modifications may be made without departing from the
scope of the present invention.

The present application is based on Japanese
25 priority application No. 11-003645 filed on January 11,
1999, with the Japanese Patent Office, the entire
contents of which are hereby incorporated by reference.

30

35

09369776-080699